Neighborhood disadvantage and immune-related illnesses among residents living in the US Gulf States

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ARTICLE INFO

Article history:
Received 12 July 2022
Revised 20 December 2022
Accepted 23 December 2022
Available online 28 December 2022

Keywords:
Neighborhood disadvantage
Socioeconomic factors
Immune health
Epidemiology

ABSTRACT

Purpose: Neighborhood disadvantage has been associated with increased risk for pneumonia and influenza-associated hospitalizations. Few studies, however, have investigated how neighborhood disadvantage may influence immune-related illnesses.

The aim of this study was to examine the association between neighborhooddisadvantage and immune-related illnesses.

Methods: We used data from the Gulf Long-term Follow-up (GuLF) Study (n = 32,608). Our analytic sample included home visit participants (n = 11,193) who had complete information on exposure and covariates (n = 10,543). Neighborhood disadvantage was assessed using the 2013 Area Deprivation Index (ADI), which assigns a ranking of 1 to 100 for lowest to highest disadvantage. We linked ADI to participants' geocoded enrollment addresses at the census block group level. ADI was categorized into quartiles based on the national distribution with the first quartile as the referent. Immune-related illnesses self-reported at the home visit (May 2011–May 2013) included occurrence of shingles, pneumonia, cold sores, flu, and colds since the Deepwater Horizon oil spill (April 2010). Frequent colds and frequent flu were defined as ≥4 colds and ≥2 episodes of flu since the spill. An aggregated outcome, based on occurrence of any pneumonia, cold sores, flu, and ≥4 colds since the spill, was also examined. We assessed the association of each outcome with ADI using multivariable log-binomial regression adjusting for individual-level demographics, behavioral factors, kids at home, and season of interview completion.

Results: We found elevated prevalence ratios (PR) and 95% confidence intervals (CI) for pneumonia associated with ADI in the third (PR: 2.04, 95% CI: 1.04, 4.02) and fourth (PR: 2.00; 95% CI: 1.00, 3.98) quartiles. PRs for frequent colds were also elevated for increasing ADI quartiles, but with confidence intervals including the null value.

Conclusions: The observed associations of frequent colds and pneumonia with increasing neighborhood disadvantage may warrant further research on this topic

Introduction

Neighborhood disadvantage has been linked to risk for pneumonia and influenza-associated hospitalizations [1–7]. The Area Deprivation Index (ADI) is a factor-analysis based index that uses 17 US Census poverty, education, housing, and employment indicators to characterize neighborhood disadvantage at the census-block group level. It has greater spatial resolution than other available census-based measures of neighborhood socioeconomic status (SES) [8]. Two studies used the ADI as a measure of neighborhood level socioeconomic status, while other studies used measures such as percent below poverty and household crowding [1–5,7]. One of the studies that used ADI reported increasing neighborhood disadvantage was associated with increased risk of

The authors have no conflicts of interest to disclose.

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https://doi.org/10.1016/j.annepidem.2022.12.012

rehospitalization within 30 days for pneumonia [2]. Another study examined ADI in relation to community-acquired pneumonia (CAP) and found high neighborhood disadvantage was associated with an increased incidence of CAP compared to low neighborhood disadvantage [1].

Existing studies have evaluated only a single health outcome at a time, providing an incomplete picture of the impact of neighborhood disadvantage on immunologic health. Additionally, definitions of neighborhood disadvantage vary across the literature, often relying on census-tract based measures. We aimed to examine the association between neighborhood disadvantage using ADI and multiple health endpoints as general markers for potential immune suppression.

Methods

Study design and participants

We used data from the Gulf Long-term Follow-up (GuLF) Study, a prospective cohort study of 32,608 adults who worked on the *Deepwater Horizon* oil spill or received worker safety training but did not work on the spill [9]. Participants were at least 21 years of age at enrollment. Following the enrollment interview, English and Spanish speaking individuals residing in eastern Texas, Louisiana, Mississippi, Alabama, or Florida were invited to participate in a home visit (May 2011–May 2013) where additional health indicators of interest were ascertained [9]. We restricted our analysis to those who participated in a study home visit (N = 11,193) and had complete information on exposure and covariates for a final sample size of 10,543 participants. All participants provided consent.

Exposure assessment

Neighborhood disadvantage was assessed using the 2013 ADI, which assigns a scored based on 17 US census-based measures of poverty, education, housing, and employment and then assigns a ranking of 1 to 100 for lowest to highest disadvantage, respectively, based on national percentile rankings [2, 10]. Briefly, 17 poverty, education, housing, and employment indicators from the American Community Survey are weighted using factor score coefficients to create ADI scores [2, 10]. For the current study, we linked ADI to participants' geocoded enrollment addresses at the census block group level.

Outcome assessment

Outcomes were self-reported at the home visit and included occurrence of shingles, pneumonia, cold sores, any flu, and any colds in the past one, two, or three years, depending on the date of the home visit relative to the *Deepwater Horizon (DWH)* oil spill in April 2010. Frequent colds and frequent flu were defined as four or more colds and two or more episodes of flu since the spill, respectively. An aggregated outcome, based on occurrence of pneumonia, cold sores, any flu, or four or more colds since the spill, was also examined.

Statistical analysis

We assigned participants into one of four ordinal levels of disadvantage based on the US percentile of neighborhood disadvantage as follows, quartile 1: 0–25th, quartile 2: 26–50th, quartile 3: 51–75th, quartile 4: 76–100th. The first quartile, representing least disadvantage, was the referent . A directed acyclic graph (DAG) was used to determine confounders, which included age, sex, education, race, ethnicity, smoking, alcohol use, children at home during enrollment, and season of home visit interview completion. We used multivariable log binomial regression to estimate prevalence ratios (PR) and 95% confidence intervals (CI) for the adjusted association between ADI and each outcome related to infection. We did not assess effect measure modification due to small sample sizes in stratified analyses. We conducted sensitivity analyses controlling for year of home visit interview completion due to the varying time range of 1 to 3 years in questions asked about the outcomes of interest, which depended on time between the oil spill and home visit. We also excluded individuals whose home visit took place 3 years after the oil spill in sensitivity analyses to assess the association between ADI and each outcome among those whose home visit interview took place within 2 years of the *DWH* oil spill. A separate sensitivity analysis adjusted for oil spill clean-up work exposures.

Results

In the overall cohort (N = 32,608), the mean age of participants was 44 years, and most participants were men (81%), White (64%), and performed oil spill clean-up work (76%); this was similar in the analytic sample (N = 10,543) where the mean age was 44 years and most participants were men (78%), White (55%), and performed oil spill clean-up work (80%). Among participants in this study, the highest quartile of neighborhood disadvantage included the highest proportions of people who were Black (57%), had an annual household income less than $20,000 (52%), and were unemployed at enrollment (35%). We found elevated associations for pneumonia in the second (PR: 1.97, 95% CI: 1.00, 3.90), third (PR: 2.04, 95% CI: 1.04, 4.02) and fourth (PR: 2.00, 95% CI: 1.00, 3.98) ADI quartiles compared to the first quartile in adjusted models (Table 1). Increasing ADI was associated with elevated PRs for frequent colds ranging from 1.16 (0.94, 1.42) to 1.21 (0.98, 1.48) for

Table 1
Adjusted association between United States (US) Area Deprivation Index (ADI) quartiles and immune-related illnesses since the spill among GuLF Study participants (N = 10,543)

		US ADI quartiles		
Outcome*	*Number of cases*	*Q2 (95% CI)*	*Q3 (95% CI)*	*Q4 (95% CI)*
Any colds	7392	0.96 (0.91, 1.01)	0.94 (0.89, 0.99)	0.96 (0.91, 1.01)
4 or more colds	2318	1.16 (0.94, 1.42)	1.21 (0.98, 1.48)	1.16 (0.94, 1.43)
Any flu	1755	0.91 (0.75, 1.10)	0.90 (0.74, 1.10)	0.80 (0.65, 0.98)
2 or more episodes of flu	699	0.98 (0.80, 1.19)	1.00 (0.81, 1.23)	0.92 (0.73, 1.14)
Cold sores	2088	0.96 (0.80, 1.15)	1.08 (0.90, 1.30)	1.06 (0.88, 1.28)
Pneumonia	349	1.97 (1.00, 3.90)	2.04 (1.04, 4.02)	2.00 (1.00, 3.98)
Shingles	82	0.50 (0.24, 1.04)	0.63 (0.31, 1.27)	0.49 (0.22, 1.10)
Aggregated outcome†	4647	1.01 (0.91, 1.12)	1.05 (0.95, 1.17)	1.00 (0.90, 1.12)

* Adjusted for age, sex, education, race/ethnicity, smoking, drinking, kids at home, and season of home visit interview.

† Any outcome (4 or more colds, flu, cold sore, or pneumonia) except shingles.

ADI quartiles two and three, respectively. Shingles was inversely associated with ADI but this was based on a small number of cases. The associations between ADI and flu, cold sores, and the aggregated outcome were largely null. In sensitivity analyses adjusting for year of home visit interview completion and oil spill clean-up work exposures, we did not observe any meaningful differences in prevalence ratio estimates (results not shown). In analyses that excluded individuals whose home visit took place 3 years after the *DWH* oil spill, the association of ADI with frequent colds was stronger and with pneumonia was attenuated; associations with remaining outcomes were similar.

Discussion

This is the first study we are aware of to investigate neighborhood disadvantage in relation to multiple possibly immune-related illnesses. Our findings agree with prior studies that have reported associations of ADI with increased risk of rehospitalization within 30 days for pneumonia [2] and incidence of CAP [1]. It is possible that associations with pneumonia were detectable due to a lower likelihood of misclassification due to recall bias since self-reported outcomes are subject to misreporting. We had limited statistical power for the less commonly occurring shingles. The time between the oil spill and home visit interview ranged from one to three years. Although adjusting for year of home visit interview in sensitivity analyses did not change results, there is still potential for residual confounding. We investigated potential clustering by neighborhood using the inter-correlation coefficient (ICC) and found no evidence of clustering that would bias our estimates (ICC$<$0.3). Study strengths include the use of ADI to measure neighborhood disadvantage, a socioeconomically diverse population, and a relatively large sample size. While ADI is a measure of neighborhood disadvantage based on census block group poverty, education, housing, and employment, it may also indirectly serve as a measure of other structural determinants of health such as environmental exposures, access to medical care, and availability of social and community support.

Conclusion

Findings of the current study suggest that living in a disadvantaged neighborhood may increase the risk of having frequent colds and pneumonia, though longitudinal research using more robust measures of immune-related illnesses are needed to clarify this relationship.

Data availability

Requests for the data used in this analysis may be submitted to the GuLF Study following instructions on the GuLF Study website – https://gulfstudy.nih.gov. Collaborators interested in conducting research using the GuLF Study may contact one of the study investigators or submit a request by following the link at https://gulfstudy.nih.gov/en/forresearchers.html.

Author contributions

Kaitlyn G. Lawrence designed this study and Opal P. Patel performed statistical analyses and wrote the manuscript. Kaitlyn G. Lawrence assisted with statistical analyses, interpretation of results, and manuscript writing. Mark Bodkin and William Braxton Jackson III reviewed and assisted with statistical analyses. Dale P. Sandler and Lawrence S. Engel are GuLF Study Principal Investigators. They supervised study design, statistical analyses, interpretation of results, and manuscript writing. All authors reviewed and edited the manuscript.

Ethical approval

This study was approved by the Institutional Review Boards of both the National Institutes of Health and the University of North Carolina.

Acknowledgments

We thank GuLF Study participants and all former and current GuLF STUDY staff at Social & Scientific Systems, Inc a DLH holding company. This work was supported by the Intramural Research Program of the National Institutes of Health, the National Institute of Environmental Health Sciences (Z01 ES 102,945 to DPS).

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